Power Integrity through PDN Impedance Measurement

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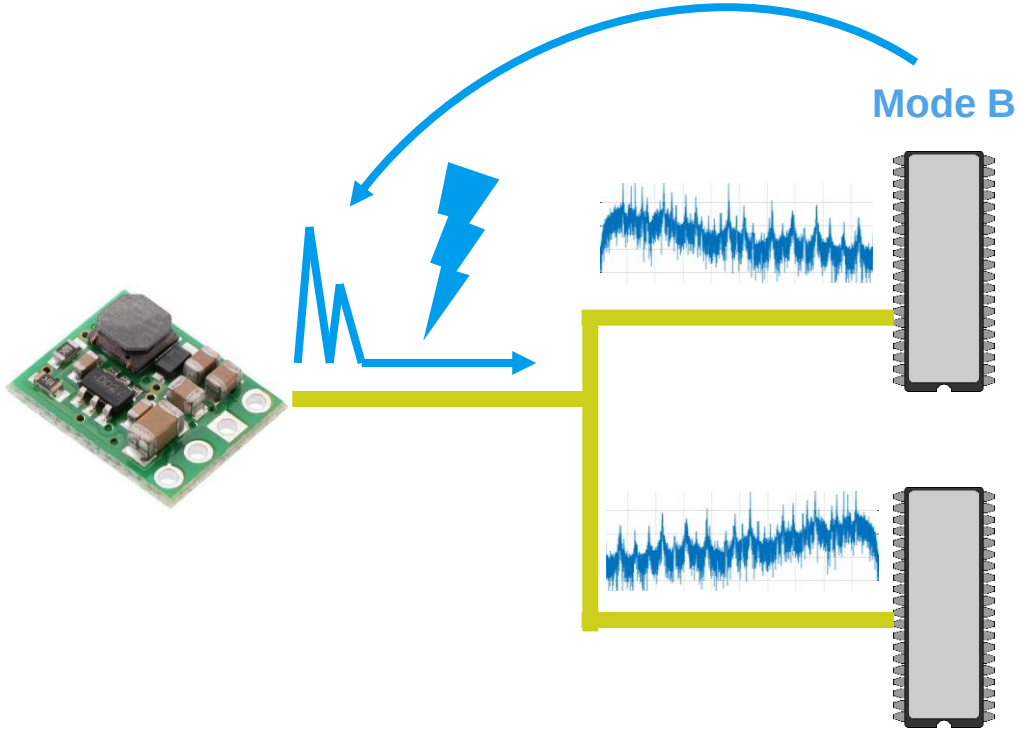
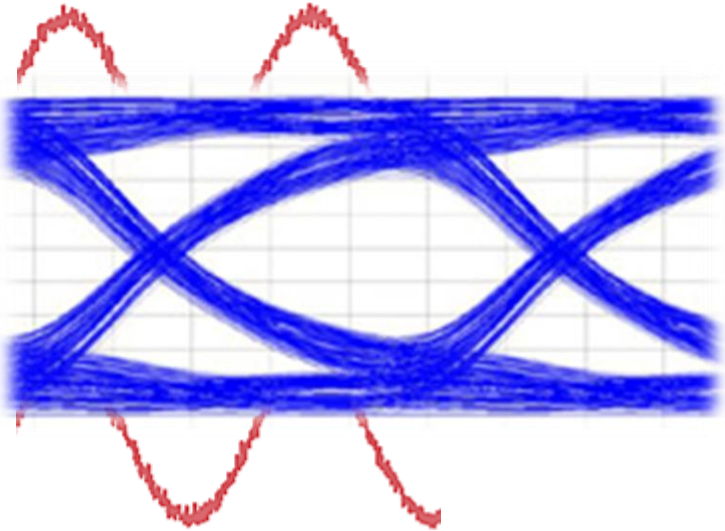
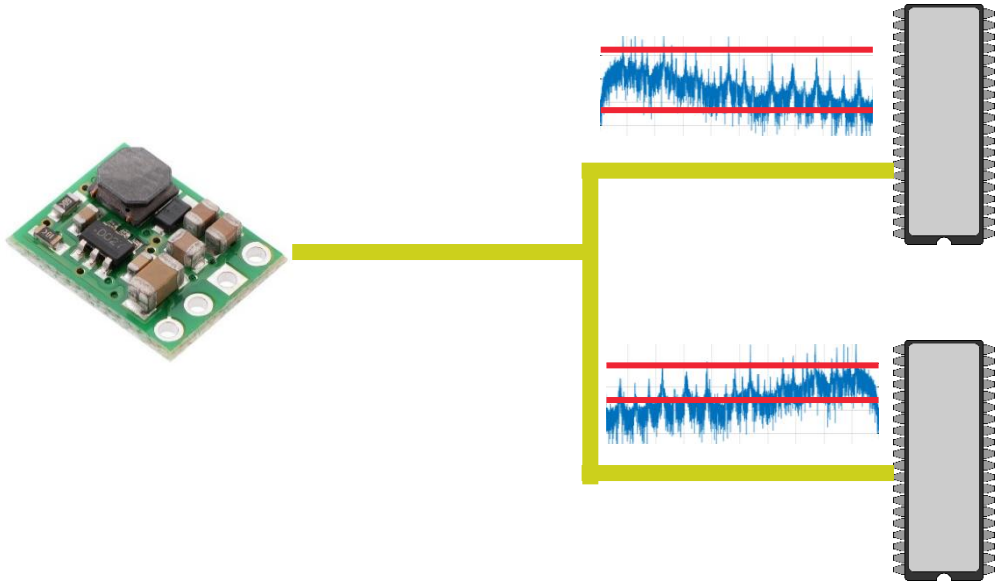
ROHDE&SCHWARZ

Power Integrity and Signal Integrity





Power Integrity and Signal Integrity



Usually small value!

$$Z_{PDN\ target} < \frac{V_{L\ noise}}{I_{L\ worst-case}}$$

Power Delivery Network = Transmission Line

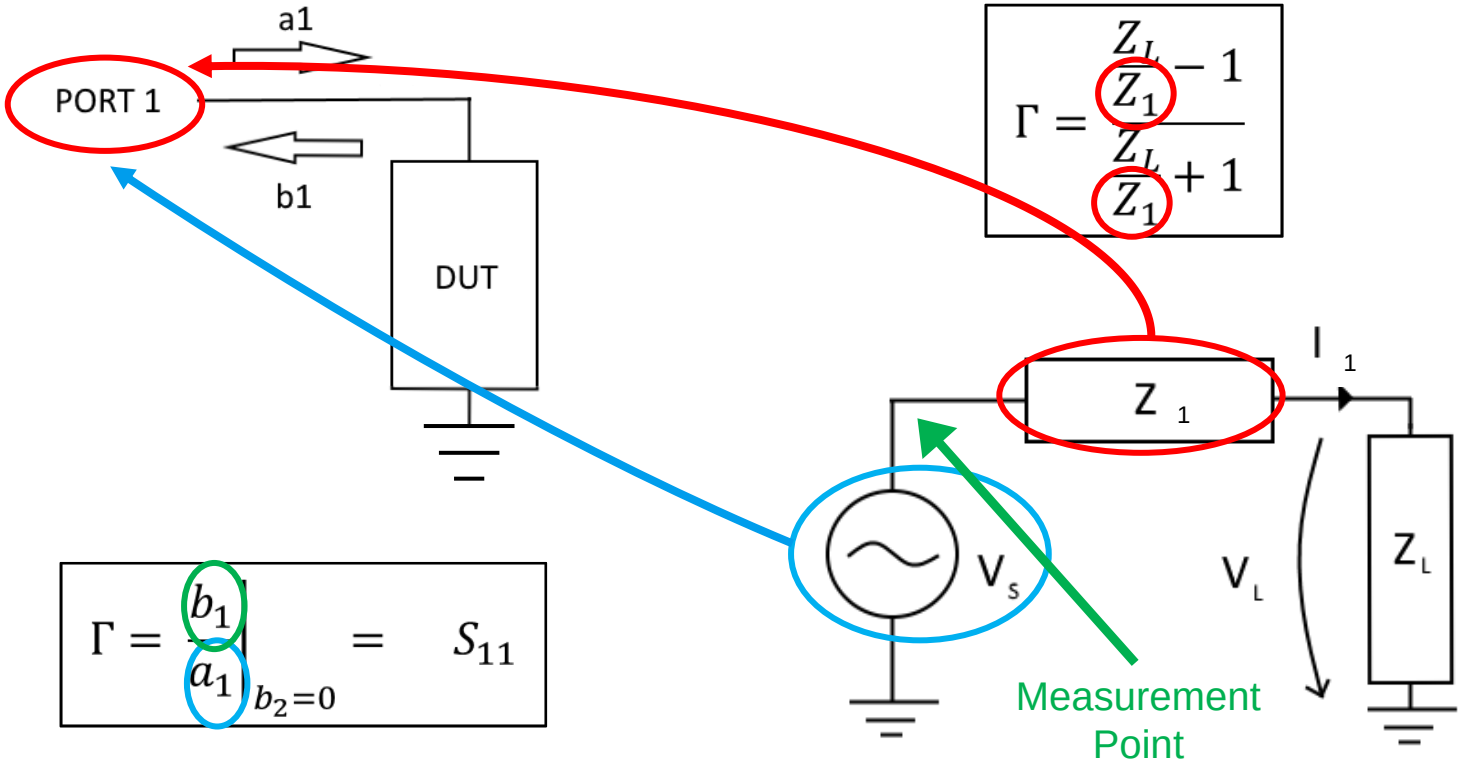
How to Measure Impedance with VNA

1. Reflection setup

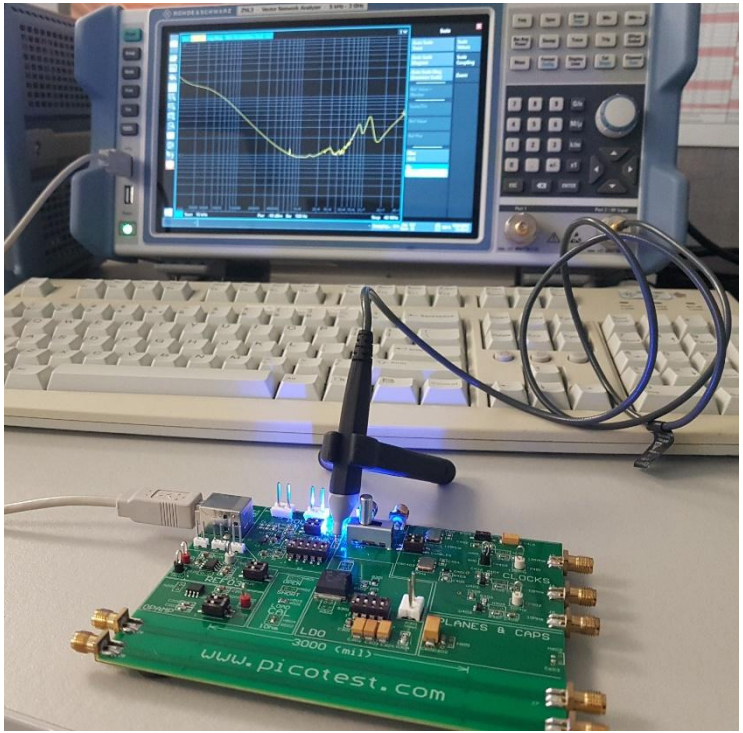
2. Transmission setup

3. Shunt-transmission setup

Reflection setup



Reflection setup

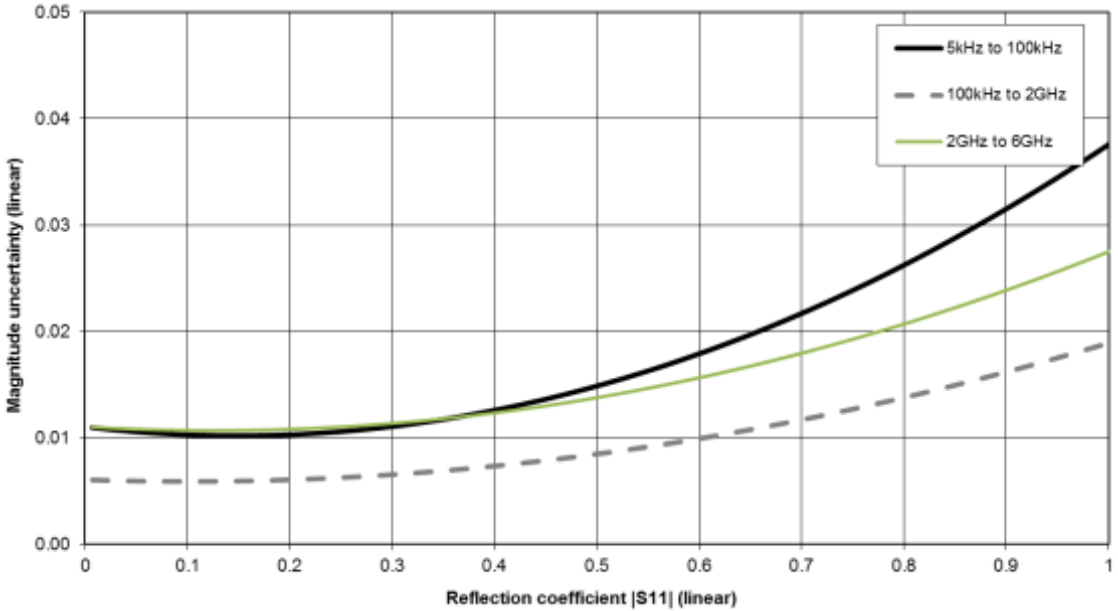


$$Z_L = Z_1 \cdot \frac{1 + S_{11}}{1 - S_{11}}$$

Z probe = 50 Ω → Z_1 = 50 Ω

Z probe ≠ 50 Ω → Z_1 = 50 Ω + Probe Z

Reflection setup – Validity



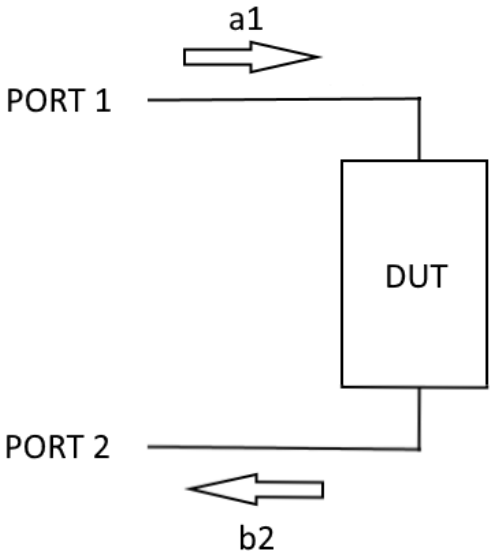
$$Z_L = 50 \cdot \frac{1 + S_{11}}{1 - S_{11}}$$

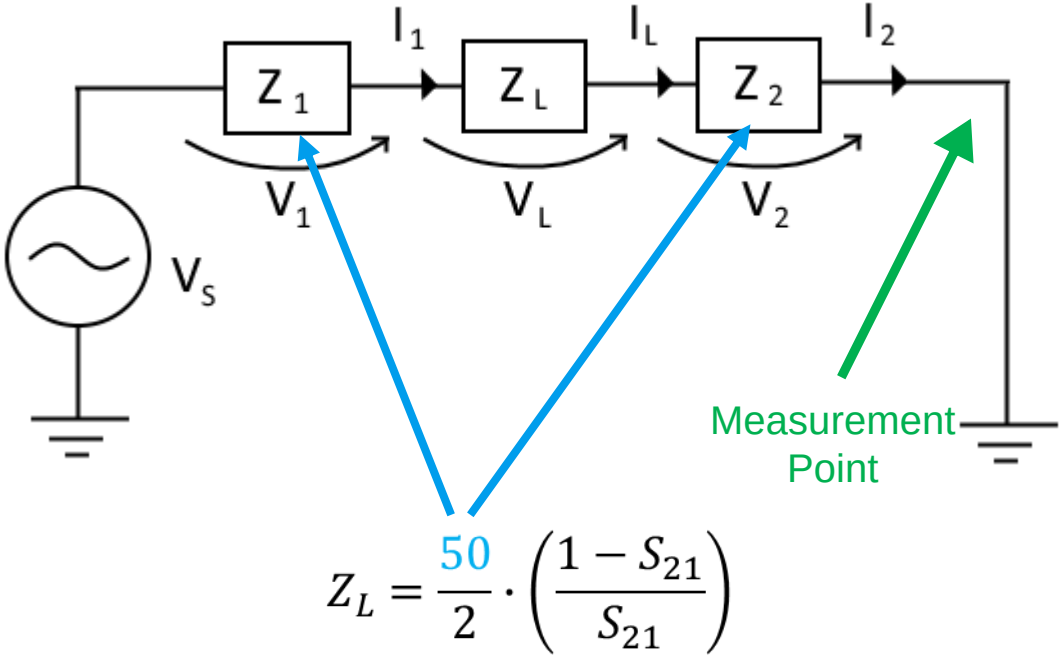
Most wave reflected
(Γ → 1)?

High uncertainty!

Approx. 10% uncertainty
between 10 Ω and 200 Ω

Transmission setup

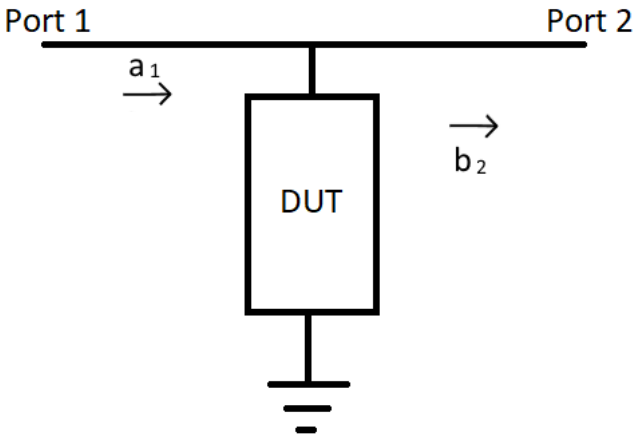


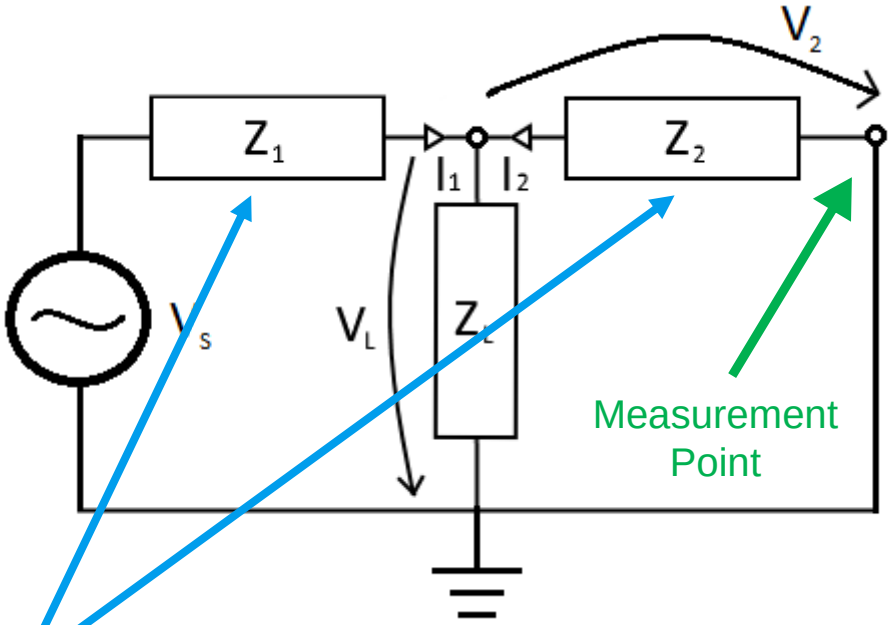


$$Z_L = \frac{50}{2} \cdot \left(\frac{1 - S_{21}}{S_{21}} \right)$$

Can only measure high Z

Shunt-Transmission setup





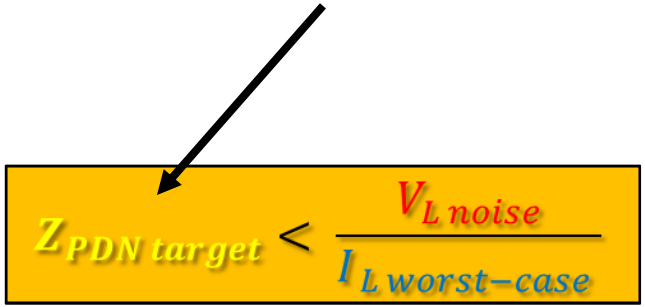
$$Z_L = \frac{50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

Shunt-Transmission setup

$$Z_L = \frac{50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

Can measure in mΩ range

Usually small value!



Shunt-Transmission setup

Not enough Z span?

Can measure in mΩ range

$$Z_L = \frac{Z_0}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

Use high-Z probes!

Shunt-Transmission setup

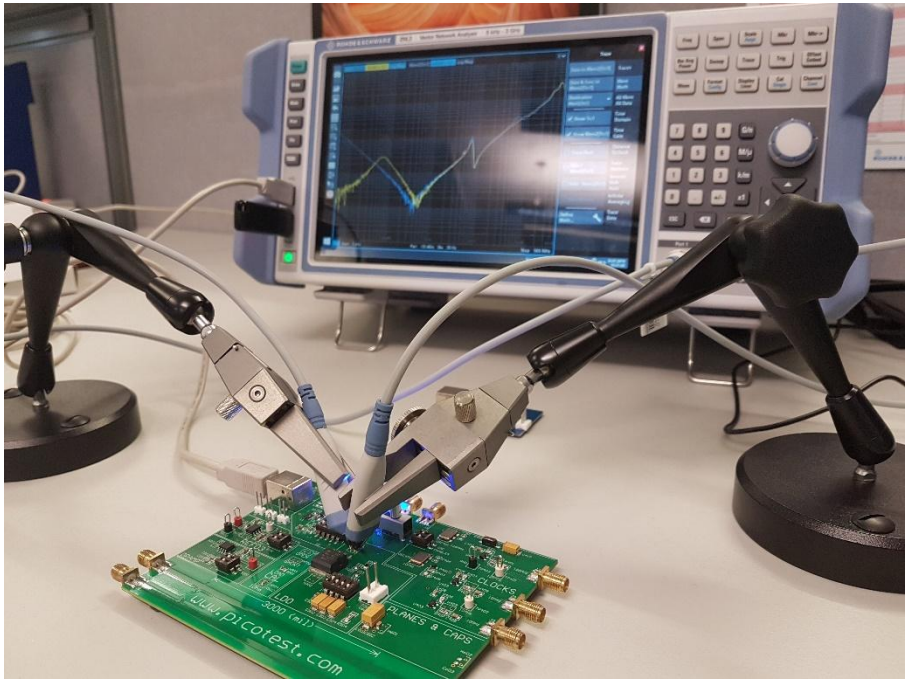
Approx. 1 * mΩ to 1 * kΩ

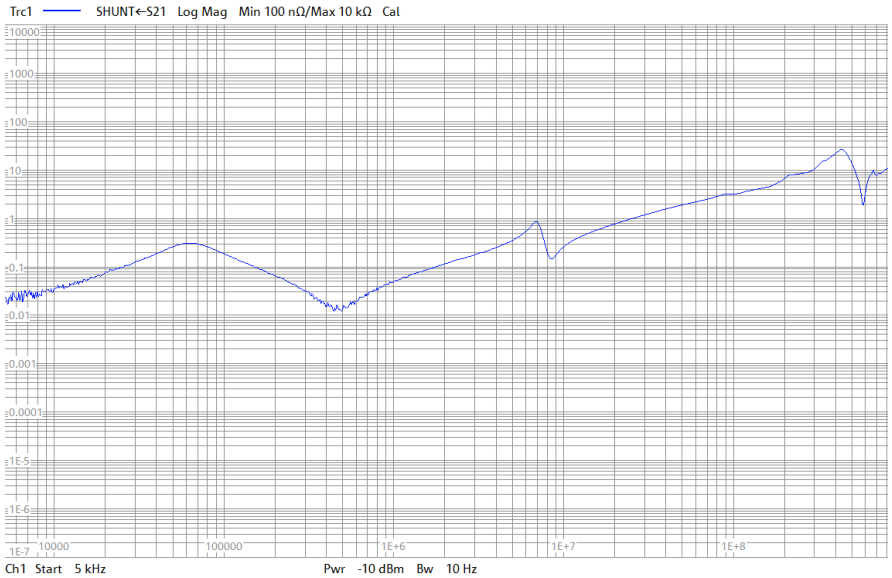
$$Z_L = \frac{50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

$$Z_L = \frac{10 \cdot 50}{2} \cdot \left(\frac{S_{21}}{1 - S_{21}} \right)$$

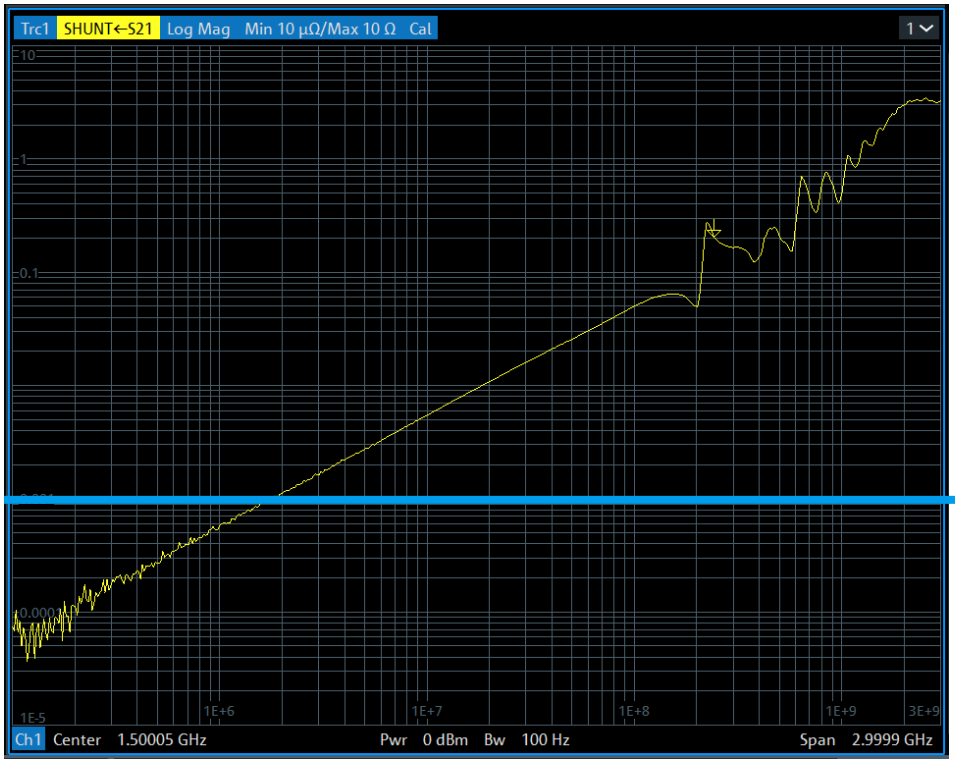
Approx. 10 * mΩ to 10 * kΩ

Shunt-Transmission setup – 10:1 probes





Shunt-Transmission setup – only cables



Measurement of
32µΩ (@ DC) resistor

1mΩ